



Manitoba Floodway Authority

**Red River Floodway Expansion Project
2011 Groundwater Monitoring Activity Report
.999923 HM78
FINAL REV 0
March 2012**

Prepared By

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Approved By

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Winnipeg, Manitoba**



March 26, 2012

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ATTENTION: Ms. Leanne Shewchuk
Manager, Environmental Services

RE: Red River Floodway Expansion Project
2011 Groundwater Monitoring Activity Report
Memo Reference: .999999.01 HM78
Final Report – March 2012

Dear Ms. Shewchuk:

Please find enclosed twenty (20) copies of the Final 2012 Groundwater Monitoring Activity Report. The report combines requirements for annual monitoring in Environmental Licence 2691 (including construction monitoring) for the 2011 period. Because of privacy issues and the volume of data, detailed information is not presented here, but will be made available to the Manitoba Floodway Authority if required.

We appreciate the opportunity to provide on-going services to the Manitoba Floodway Authority on this project.

Sincerely,

Original Signed By: J. Bert Smith

cc: Mr. Dave MacMillan, Project Manager – KGS Group

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FIGURES

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HM78-1 Domestic Well Monitoring Locations 2011

1.0 INTRODUCTION AND AQUIFER CHARACTERIZATION

This 2011 Groundwater Monitoring Activity report is submitted in response to the requirements for annual (construction) monitoring in accordance with Clause 27 and Clause 30 of Environmental Licence No. 2691 dated July 8, 2005. Groundwater activities for 2005 and 2006 were summarized in the 2006 Groundwater Monitoring Activity Report issued March 2007, which should be used as a reference to this report.

Activities for 2007 to 2010 are summarized in the annual 2007 to 2010 Groundwater Monitoring Activity Reports, respectively, issued in March or April after the respective year ends.

Groundwater monitoring results in 2011 represent post construction monitoring. The only activities carried out in 2011 were the Inlet Structure Modifications, which do not have potential to affect groundwater, and the Groundwater Discharge Spring Treatments, a mitigation measure completed prior to 2011 monitoring.

During the 2011 spring flood event, the Red River water began naturally flowing into the Floodway Channel on April 5, 2011 when the water levels rose above an elevation of 228.6 m (750 ft). The Floodway gates were in operation for 55 days from April 9 to June 2, 2011. The Red River crested on May 4, 2011 at an elevation of 232.89 m (764.08 ft) at the Floodway Inlet with a flow of 2130 m³/s (75,200 cfs) in the Red River and 1019 m³/s (35,300 cfs) diverted into the Floodway Channel.

Summer Floodway Operation – There was an eight-day summer Floodway Operation event from July 7, 2011 to July 15, 2011, with a channel crest on July 10, 2011 at an elevation of 229.37 m (752.54 ft) with a flow of 920 m³/s (32,500 cfs) in the Red River and 64 m³/s (2259 cfs) diverted into the Floodway Channel.

Initially flood predictions indicated that the 2011 spring event could exceed the 2009 flood flow. The actual spring 2011 flood was somewhat smaller than the spring 2009 flood in channel elevation (231 versus 232 m at TCH 1) and discharge in the channel of 1019 m³/s versus 1208 m³/s, but the 2011 event had a slightly longer duration (55 versus 47 days).

The purpose of the groundwater monitoring program is to monitor the effects of construction during Floodway expansion and to determine whether Floodway expansion has resulted in potential effects on local groundwater. Another objective of the program is to identify the potential for water quality changes and to characterize the nature of any water quality changes found in the groundwater. This includes evaluating if Floodway Operation is a source of the water quality change, or if other sources and factors are more likely. Both groundwater and surface water data are collected as part of the monitoring program.

Two events were monitored in 2011:

- March 2011 – pre-spring run-off (no Floodway Operation) (monitoring wells)
- April to June 2011 – Floodway Operation (monitoring wells and limited domestic well monitoring and surface water monitoring)

Domestic wells and monitoring wells were not sampled during the July 2011 summer Floodway Operation event that lasted only eight days. Groundwater data from transducers is available for this event at several locations. Surface water samples also were taken during the summer flood event.

The carbonate aquifer found along the Floodway Channel is part of a regional flow system from eastern Manitoba. The confined carbonate bedrock aquifer has natural variations in water quality, with the conductivity ranging from moderate to high (1,000 to 2,000 $\mu\text{S}/\text{cm}$). Near the Floodway Inlet, local mixing with saline groundwater found west of the Red River results in higher conductivity groundwater (greater than 3,000 $\mu\text{S}/\text{cm}$) with increased chloride and sodium. Conductivity is a measure of dissolved solids, such as calcium, magnesium, chloride, sodium and sulphate.

Lower conductivity values are found in the bedrock aquifer where it is influenced by the Birds Hill surficial granular aquifer, from CPR Keewatin Bridge to Church Road. The Birds Hill sand and gravel surficial aquifer is a local unconfined aquifer near PTH 59N Bridge. The bedrock aquifer beneath and surrounding the Birds Hill deposit has lower groundwater conductivity due to the freshwater recharge through the sand and gravel.

Natural variations in groundwater quality by location and with the seasons must be considered when the baseline and ongoing water quality results are evaluated during construction activities and Floodway Operation events. One way to detect whether there is surface water intrusion is to monitor an indicator parameter such as conductivity. In the vicinity of the Bird's Hill sand and gravel surficial aquifer, recharge from precipitation results in groundwater with lower conductivity (500 $\mu\text{S}/\text{cm}$ to 1,000 $\mu\text{S}/\text{cm}$) than found in other areas of the carbonate aquifer.

The intrusion of any surface water into the groundwater is most readily detected when there is a contrast between the chemistry of the samples. Conductivity (along with other parameters) can be used to evaluate this contrast. Most groundwater conductivity values were found to be greater than surface water conductivity values measured during annual spring Floodway Operation. Red River conductivity values are historically lowest during spring flood events, such as in the spring of 2005, 2006, 2007, 2009 and 2010. In this situation, groundwater conductivity would be expected to decrease, if surface water intruded. During summer Floodway Operation in 2005, summer Floodway use in 2007, and summer Floodway Operation in 2010 and 2011 conductivity values of water from the Red River diverted in the Floodway were slightly higher than in the spring, and higher than the natural groundwater in some areas near the CPR Keewatin Bridge, PTH 59N Bridge and Church Road. These areas have naturally low conductivity. Floodway Channel surface water conductivity was also higher during the summer precipitation events in June 2008 than during the spring melt with no Floodway Operation in April 2008. An increase in groundwater conductivity might occur in summer if surface water intrudes into the groundwater at this time.

In the spring 2011 flood, weekly sampling in the Floodway Channel during the 8-week Floodway Operation showed that the conductivity of the surface water increased, with the lowest conductivity found at the beginning of the monitoring. Interpreting changes in groundwater water quality required consideration of the pre-flood conductivity and the changing chemistry of the potential surface water infiltration source.

2.0 POST-CONSTRUCTION MONITORING

Groundwater monitoring in 2010 was considered the first year of the 5-year post-construction monitoring since most channel excavation had been completed. Groundwater depressurization activities in 2010 were completed prior to the spring flood. The 2011 program represents the second year of the 5-year post-construction period. No further monitoring is required for construction effects, as all channel excavation and groundwater depressurization activities are complete. Post-construction monitoring will continue in 2012, 2013 and 2014, with long-term monitoring to follow focusing on key flood events in future years.

2.1 SURFACE WATER

The construction surface water monitoring program was a transition program and included a streamlined version of the previous programs. In 2011 only surface water monitoring of the Floodway Channel during Floodway Operation was retained, to provide information to interpret changes in groundwater quality. A joint sampling effort was conducted with Manitoba Water Stewardship at two of their locations in 2011: PTH 59N and St. Mary's Road Bridge.

2.2 DOMESTIC WELLS

Domestic well monitoring was conducted in 2005 to provide an initial baseline prior to Floodway expansion. Subsequent annual programs were conducted to monitor for construction effects and for potential effects during periods of Floodway Operation. The domestic well monitoring augmented the original pre-expansion water chemistry from provincial wells and the data collected from new monitoring wells installed for the Floodway Expansion Project.

In 2011 domestic well monitoring was continued in 10 locations adjacent to the new sentinel wells to provide a transition between construction monitoring programs (incorporating large domestic well and monitoring well sampling programs) and the long-term monitoring programs that will rely on monitoring wells. Additional bacteria monitoring in 40 domestic wells was added on a one-time basis because the 2011 spring flood was projected to be a large magnitude event.

Monitoring of the domestic wells has now been phased out for the remainder of the post-construction (2012, 2013 and 2014) and long-term monitoring program (2015 and beyond) now that channel expansion construction has been completed. Monitoring wells installed under controlled conditions along the channel Right-of-Way are preferred for on-going sampling programs, to avoid potential limitations due to access, as well as varying age, construction, and maintenance of the domestic wells.

The distribution of the domestic wells monitored is shown on Figure HM78-1. Homeowners participating in the program have received provincial fact sheets on well maintenance and well disinfection. Where bacteria results were positive, homeowners were contacted by phone and directed to the Office of Drinking Water for any further well-related questions. Individual well owners received copies of their laboratory analysis after each sampling event.

A variety of factors can contribute to changes in domestic well water quality. This can make detection of possible surface water intrusion from the Floodway difficult to interpret. Infiltration from septic fields or unsanitary conditions in the well, or local surface water infiltration may introduce bacteria or nitrates, unrelated to Floodway Operation. Location near gravel pits, ponds or creeks may also cause bacteria and nitrates to enter the well. If local surface water sources infiltrate and move to the well, the resulting water quality changes are often similar to those potentially caused by Red River water infiltrating via the Floodway.

Since the Floodway receives surface water from the Seine River and various municipal drains and outfalls, the channel can carry a substantial flow, even when the gates are not operated to allow the Red River to enter. Periods of high rainfall in the summer can also fill the base of the Floodway such as occurred in early July and early August 2009. These events were correlated to groundwater elevation changes. In some cases, water quality changes were monitored in areas where recharge or infiltration occurred.

2.3 MONITORING WELLS

The 2011 post-construction monitoring program included Floodway monitors used in the later part of the construction monitoring program (generally 2009 and after) to provide continuity. Seven new sentinel monitoring wells drilled at four locations in March 2011 were also added to

the program. The number of monitoring locations chosen was based on the size of the projected flood, in accordance with the preliminary development of the post-construction monitoring plan.

In the spring 2011 Floodway Operation, monitoring well samples were collected within the Floodway Channel Right-of-Way from approximately 27 bedrock wells, one till well adjacent to the Floodway, plus three sand and gravel wells (PTH 59N and Oasis Road area). Monitoring wells are not used for water supply and are not domestic wells. Monitoring well locations sampled in 2011 are shown in Figure HM78-1. Conductivity in the monitoring wells generally shows the same distribution along the Floodway as for the domestic wells. Bacteria were sampled in select sentinel wells in 2011.

3.0 SURFACE WATER RESULTS AND ASSESSMENT

The cold temperature of the Red River at the beginning of the melt is generally useful as an indicator of surface water infiltration when the river temperature is a few degrees above freezing and the groundwater temperature is higher. However, in the 2011 spring flood temperature was of limited use because the river had already risen to 3 to 4°C four days after the Floodway Operation started on April 13, 2011. Temperatures continued to increase to 5 to 9°C by May 2, 2011, overlapping with the typical range of groundwater temperatures. Temperature became more useful during the peak and later portions of the flood when surface water was at 13 to 15°C, higher than the groundwater temperatures.

Total Coliform and *E. Coli* are present in the surface water; however, the concentrations during the spring flood are lower than during the summer, as shown by the summer flood data. In the 2011 spring flood, Total Coliform bacteria in surface water was present in the 150 to 300 MPN/100 mL range during the bulk of the flood (mid-April to mid-May), with *E. Coli* of 6 to 20 MPN/100 mL.

The maximum concentration of nitrate plus nitrite (as nitrogen) measured was approximately 2.0 mg/L near the beginning of the flood on April 13, 2011. Nitrate plus nitrite (as N) decreased for each successive week of the flood to 0.1 mg/L on May 31, 2011. The maximum concentration measured in the river water was below the CCME criteria for nitrate plus nitrite (as N) in drinking water (10 mg/L); however, background groundwater concentrations are generally below 0.1 mg/L in many areas of the Floodway. Ammonia, phosphorous and total suspended solids also followed a decreasing trend as the flood progressed.

Surface water conductivity increased during the flood from 480 µS/cm on April 18, 2011 to 771 µS/cm on May 31, 2011, reflecting the increase in dissolved solids. There was a generally stable water type with a minor change due to an increase in sulphate concentration. Conductivity and major ions increased as nitrate plus nitrate (as N) and bacteria decreased during the Floodway Operation period.

The summer flood conductivity in the channel was 850 $\mu\text{S}/\text{cm}$, higher than the spring flood, due to elevated dissolved solids. The nitrate plus nitrite (as N) value was 0.1 mg/L, slightly lower than measured at the end of the spring flood, however both Total Coliform bacteria (1380 MPN/100 mL) and *E. Coli* (60 MPN/100 mL) were much higher than the spring flood.

4.0 GROUNDWATER RESULTS BY AREA

4.1 FLOODWAY OUTLET

At the Floodway Outlet, monitoring wells located 65 m and 160 m north of the expanded channel within the Right-of-Way, showed evidence of surface water intrusion in 2011. Temperature decreases, conductivity decreases, and stable isotope data support a Floodway source for this change. The monitoring well at Rockhaven Road, 350 m north of the expanded channel did not encounter the highly transmissive zones found near the Outlet and did not show a water quality or stable isotope response. Two domestic wells in the area showed a defined water quality change; however, the change in water type throughout the 2011 spring flood was different than the changes seen in nearby monitoring wells. These water quality changes were not consistent with the surface water intrusion from the Floodway as seen in the monitoring wells. This suggests that the domestic well changes may be influenced by a variety of factors independent of, or in conjunction with surface water from Floodway Operation. These factors may include local recharge through the thinner clay deposits north of the Outlet, local water quality changes due to the septic influences, or changes in the movement of the saline groundwater found in the other domestic wells west and east of these two wells.

4.2 PTH 44 BRIDGE AND CEMR BRIDGE

Surface water infiltration from the Floodway is likely at the PTH 44 Bridge west side, based on the major ion decreases in a monitoring well located inside the floodway Right-of-Way during the 2011 flood, and the previous 2009 shift in water type from groundwater towards the surface water type. There was no evidence of surface water infiltration at the CEMR Bridge in 2011. A nearby domestic well shows evidence of a possible water type change that would indicate a surface water source other than the Floodway.

4.3 HAY ROAD

Surface water intrusion was not evident at Hay Road. A small change can be seen at a monitoring well on the Floodway shoulder within the west Right-of-Way; however, the decrease in water quality major ion concentrations extends beyond the Floodway Operation period,

indicating a poor connection to the Floodway and indicating recharge sources other than the Floodway. The water quality at this well is also much higher in dissolved solids than the other three wells at this location, indicating less potential connection to surface water sources. A monitoring well located west of the Floodway Right-of-Way showed no change in water quality during the 2011 spring flood.

4.4 CHURCH ROAD, LUDWICK ROAD AND DUNNING ROAD

Surface water intrusion was seen at a monitoring well within the Right-of-Way at Church Road in 2011; however, the two domestic wells monitored in this area were not affected. At Ludwick Road, there was no evidence of surface water infiltration in the monitoring well within the Right-of-Way in 2011. The high piezometric surface due to the regional recharge at Birds Hill Park makes the potential for infiltration low at Ludwick Road. A water quality change was present at Dunning Road during and after the 2011 spring flood with a time lag similar to Hay Road. The source is most likely local recharge from the nearby Birds Hill Aquifer. Nearby domestic wells were not affected.

4.5 OASIS ROAD

Monitoring wells at Oasis Road showed no evidence of surface water intrusion during the 2011 monitoring. Wells monitored included the overburden well between the Floodway and the R.M. of East St. Paul wells, the overburden well between the Oasis Road cutoff and the Ski Hill, and the bedrock well southeast of the cutoff well close to the channel.

4.6 PTH 59N BRIDGE

Short-term infiltration of Floodway surface water into the bedrock aquifer was documented in 2011 at the PTH 59N Bridge (west side) at bedrock wells located within 40 to 60 m of the west channel slope within the Floodway Right-of-Way, and a bedrock well 250 m west of the expanded channel within the Right-of-Way, at the west Right-of-Way. The sand and gravel well immediately west of the channel also showed a short-term moderate decrease in conductivity. The sand and gravel well is west of the cut-off wall (e.g. away from channel side), installed close to the bedrock surface on the west side of the channel. There is potential for surface water to

infiltrate through the channel to the bedrock, and influence the sand and gravel well. This response was consistent with previous years monitoring close to the channel. The till well 250 m west of the expanded channel at the west Right-of-Way also shows evidence of surface water intrusion.

Groundwater quality changes occurred concurrently with water level changes at this location with little time lag. The groundwater quality returned to a typical pre-melt groundwater composition by the time the spring run-off flow in the Floodway Channel had discharged from the channel, and flow was back to the Low Flow Channel (LFC) water level.

The response in this area may represent an initial local recharge through the sand and gravel overburden, followed by infiltration of Floodway surface water.

4.7 KEEWATIN BRIDGE, PTH 15 BRIDGE AND AREA TO THE SOUTH

There was evidence of surface water intrusion within the Floodway Right-of-Way in 2011 at monitoring wells at and south of the Kildare Pumping Station based on the decreases in conductivity and major ions and the corresponding increase in nitrate plus nitrite (as N).

There was evidence of surface water infiltration within the Floodway Right-of-Way at the west bridge abutment at the CPR Keewatin Bridge in 2011 based on decreasing alkalinity and sulphate and increasing nitrate plus nitrite (as N).

There was no evidence of surface water infiltration in 2011 at the wells monitored at CNR Redditt, Branch II Aqueduct, TCH 1 Bridge, DeMeyer Road or PTH 59S Bridge.

At the Floodway inlet, the water quality change seen in 2011 appears to be due to surface water infiltration; however, the lack of change in nitrate plus nitrite (as N) suggests movement of fresher groundwater into the well due to the movement of the saline groundwater boundary to the west during the flood.

5.0 GROUNDWATER RESULTS AND ASSESSMENT

5.1 BACTERIOLOGICAL QUALITY- DOMESTIC WELLS

Domestic wells are located outside of the Floodway Right-of-Way. Domestic well samples were analyzed for Total Coliform and *E. Coli*. Total Coliform was detected in 11 of the 50 domestic wells sampled for bacteria, or 22%. *E. Coli* was detected in 1 well (2%). The Guidelines for Canadian Drinking Water Quality for Total Coliform and *E. Coli* are 0 per 100 ml. Two of these 11 wells (located near the Outlet and the CEMR Bridge) had full water quality analyses and both of these also showed minor changes in water quality during the spring flood, in addition to the bacteria detection. The change in the percentage of Total Coliform detected reflects the variations in wells sampled from event to event or year to year. In 2011 sampling was focused on more sensitive groundwater areas in order to optimize the information gained and to correlate information with bacteria data from sentinel wells.

Positive detections of Total Coliform bacteria in 2011 occurred near the Floodway outlet (six wells), from CEMR Bridge to Hay Road (one well), from Hay Road to Church Road (two wells) and PTH 59N East Side (two wells). Floodway Operation is one potential source of bacteria; however, there is a variety of other sources of bacteria potentially influencing the groundwater quality such as spring melt conditions or in-well effects. All wells are assumed to be developed in the bedrock aquifer based on drilling records examined in selected areas.

Monitoring of bacteria and water quality in domestic wells in previous years has shown that bacteria presence can occur with or without a change in water chemistry as shown by major ions. Wells where water quality changes occur at the same time as bacteria changes have a greater likelihood of having a Floodway source than wells where bacteria is detected with no other water quality change. Domestic well monitoring in 2011 focused on bacteria analysis and included chemical analyses in a small number of wells, therefore limited conclusions can be drawn about the source of bacteria in 2011.

5.2 NITRATE PLUS NITRITE (AS NITROGEN)

5.2.1 Domestic Wells

Domestic wells are located outside of the Floodway Right-of-Way. Most nitrate plus nitrite (as N) values in domestic wells throughout the study area are historically well below the Canadian Drinking Water Quality Guideline (CDWQG) value of 10 mg/L nitrate plus nitrite (as N). In March 2011, 44%, or 4 of the 9 samples were less than detection (0.07 mg/L) and 56%, or 5 of the values were between 0.07 and 1 mg/L.

In April 2011, 42%, or 5 of the 12 samples were less than detection, 42%, or 5 of values were between 0.07 and 1 mg/L and 16 or two of the values were between 1 and 2 mg/L (at the Outlet structure).

5.2.2 Monitoring Wells

Monitoring wells are located within the Floodway Right-of-Way. In the monitoring well samples, most nitrate plus nitrite (as N) concentrations were low in 2011 and lower than surface water levels during Floodway Operation (a maximum of approximately 2 mg/L). In March 2011, 49% or 16 of the 33 values were less than <0.07 mg/L, 39%, or 13 were between 0.07 and 1 mg/L, 12%, or 4 were between 1 and 3 mg/L (at the Outlet and PTH 44 Bridge). All values in March and April 2011 were below the Canadian Drinking Water Quality Guidelines for nitrate plus nitrite (as N), 10 mg/L.

In April 2011, 42%, or 14 of the 33 samples were less than <0.07 mg/L, 46%, or 15 were between 0.07 and 1 mg/L and 12%, or 4 were between 1 and 2 mg/L (Outlet and PTH 44).

5.3 CONDUCTIVITY AND MAJOR IONS

Conductivity changes are being used as an indicator of surface water influence on groundwater quality, as conductivity is a parameter that is readily measured. Conductivity changes reflect the changes in major ions contributing to the dissolved solids.

If surface water intrudes into the aquifer, the mixing would result in changes observed in groundwater conductivity. Conductivity decreases with the addition of surface waters in most areas. Changes are most readily observed in areas where groundwater is more mineralized and thus has higher conductivity than surface water, which is typically the case during the spring. Conversely, increases in groundwater conductivity would be seen in areas where baseline groundwater conductivity is less than that of surface waters.

In the study area, potential surface water infiltration sources are ponds and open sand and gravel quarries, and creeks, as well as the Floodway and Red River, primarily near the Floodway Outlet.

In 2011, 45 locations were sampled for water chemistry and bacteria including 33 monitoring wells and 12 domestic wells. Two ponds / pits were also sampled. The sampling points do not represent a random sample, but are concentrated largely in areas where groundwater quality changes have occurred in the past or where hydrogeological conditions (such as channel base in till versus clay) are most sensitive to surface water infiltration. Therefore the percentage of wells with groundwater changes cannot be compared from year to year. During spring monitoring in 2011, no obvious change in groundwater quality was seen in 51% (23) of the 45 monitoring and domestic wells sampled. There were 22 wells (49% of the total wells) showing possible slight to moderate decreases in conductivity. The decreases were rated as slight (5 to 10% change) for seven wells (16% of the total) and minor (10 to 25% change) for six wells (13% of the total), with the slight to minor water quality changes interspersed along the channel from Hwy 59 Bridge to the Outlet. Moderate (25 to 50% change) decreases in conductivity were noted for nine wells (20%) which were located in the Floodway Outlet area, PTH 44 Bridge, PTH 59N Bridge, Kildare and the Floodway Inlet.

5.4 RELATIONSHIP BETWEEN PARAMETERS

Five wells (11%) sampled showed changes in both conductivity and Total Coliform. Changes in nitrate plus nitrite (as N) correlated with changes in water quality in some wells (at the Outlet, and CEMR Bridge). Since the maximum nitrate plus nitrite (as N) values in surface water were approximately 2 mg/L in 2011, any higher values would be unrelated to Floodway Operation. Changes in nitrate plus nitrite (as N) within the range of surface water correlate with changes in water quality at PTH 59N west side, CPR Keewatin, Kildare and the Floodway Outlet.

Nitrate plus nitrite (as N) values changed in ten of the 22 wells where decreases in conductivity occurred in spring 2011. The increases in nitrate were less than 1 mg/L with total nitrate plus nitrite (as nitrogen) of 2.0 mg/L or less. Nitrate concentrations in these wells were below the Canadian Drinking Water Guideline of 10 mg/L nitrate (as N).

Stable isotope changes correlated well with water quality changes at the Floodway Outlet and PTH 59N. The lack of isotope changes at wells with stable water quality increases confidence that these wells were not affected during the 2011 Floodway Operation.

5.5 LOCATION OF GROUNDWATER QUALITY CHANGES

In 2011 wells with moderate changes were found as follows:

- ***Inside the Right-of-Way PTH 59N*** – One sand and gravel monitoring well at the west side of PTH 59N Bridge in overburden, and one bedrock well where the Floodway Channel invert is in sand and gravel over bedrock, and one till/sand and gravel well at the west Floodway Right-of-Way.
- ***Inside the Right-of-Way Outlet*** – Two bedrock monitoring wells inside the Right-of-Way at the Floodway outlet where bedrock is close to the channel bottom.
- ***Outside of the Right-of-Way Outlet*** – One domestic well in the area outside of the Floodway Right-of-Way. The source of the water quality in this well is influenced by factors other than the Floodway based on an analysis of water type changes.
- ***Inside of the Right-of-Way PTH 44 Bridge*** – One bedrock monitoring well at the PTH 44 Bridge west abutment where there is a high bedrock transmissivity in an upper fractured zone.
- ***Inside of the Right-of-Way of CNR Redditt and Kildare*** – One bedrock monitoring wells near CNR Redditt and Kildare in an area where the channel base is in till (G05OJ007).
- ***Inside of the Right-of-Way Inlet*** – One bedrock monitoring well at the Floodway Inlet Control Structure (G05OC006).

In 2011 wells with minor changes were found as follows:

- ***Outside of the Right-of-Way Outlet*** – One domestic well in the area outside of the Floodway Right-of-Way. The source of the water quality in this well is influenced by factors other than the Floodway based on an analysis of water type changes.

- ***Outside of the Right-of-Way CEMR*** – One domestic well at CEMR Bridge. The water type change indicates a surface water source other than the Floodway.
- ***Inside of the Right-of-Way Dunning Road*** – One bedrock monitoring well at Dunning Road.
- ***Inside of the Right-of-Way*** – Two bedrock monitoring wells at the west side of PTH 59N Bridge and at the west Floodway Right-of-Way. The minor change in conductivity reflects the similar water quality in the groundwater and surface water at this location.

The five wells with both water quality changes and Total Coliform are as follows:

- ***Inside of the Right-of-Way PTH 59N Bridge Monitoring Wells*** – West Right-of-Way and channel.
- ***Outside of the Right-of-Way CEMR Bridge*** – domestic well, however, the water type change indicates a surface water source likely other than the Floodway.
- ***Outside of the Right-of-Way Floodway Outlet*** – domestic well.

The nine wells where nitrate plus nitrite (as N) values changed when conductivity decreases occurred were as follows:

- ***Outside of the Right-of-Way Floodway Outlet*** – two domestic wells. (One is the same well noted with total coliform above).
- ***Inside of the Right-of-Way*** – one monitoring well.
- ***Inside of the Right-of-Way PTH 59N West Side monitoring wells*** – west Right-of-Way and channel.
- ***Inside of the Right-of-Way Kildare*** – two monitoring wells.
- ***Inside of the Right-of-Way CPR Keewatin*** – A change in conductivity was not seen because groundwater type is similar to surface water type at this location; however, the nitrate plus nitrite (as N) change correlated with decreasing alkalinity and sulphate.

Many of the monitoring wells are located within the Floodway Right-of-Way on the shoulder of the Floodway Channel, or in the spoil pile, and would be expected to experience any water quality changes more quickly than domestic wells located further away, beyond the Floodway Right-of-Way. Travel times to the wells vary depending on Floodway Channel water elevations, groundwater elevations and the hydraulic conductivity of the bedrock, which varies from highly

fractured to massive. In general, groundwater gradients will be greater and their travel times will be shorter closer to the Floodway. Gradients will decrease and travel times will lengthen further from the Floodway.

In cases where conductivity changes appeared to be correlated to Floodway use in the spring, the maximum change correlated with conditions of peak flow and surface water elevation during the Floodway Operation period. Water quality started returning to typical pre-spring melt groundwater concentrations after the peak flow dropped and reached pre-melt conditions soon after Floodway Operation ended.

6.0 SPRING TREATMENT AREAS

The Spring Treatment Program has mitigated surface water infiltration in the bedrock aquifer by providing sand filtration of any fines migration, by decreasing the amount of flow into the springs at the filter locations for a given flood, and by improving the bacterial quality of any infiltrating water. The constructed fine sand filters have a much lower hydraulic conductivity than an open fracture; therefore, the initial flow rate is decreased. As the low permeability silt fraction builds up above the sand filter layer, the infiltration rate is reduced further. The fine sand also meets criteria for slow sand filters designed to reduce bacteria passage through the filter. After the flood, when the flow direction reverse to groundwater discharge, the sand filter protects against upward piping of the foundation material (silt, sand) which otherwise could have increased the size of a fracture/hole.

Sealing the groundwater discharge areas completely is not desirable, as a pressure build-up and uncontrolled discharge in another area would likely develop. The treatments provide pressure relief, but in a controlled fashion and with a flow rate lower than was present before treatment.

The sampling of treated springs in 2009 through 2011 shows that Total Coliform and *E. Coli* bacteria are generally present and at higher levels above the filter. The filter has been effectively reducing Total Coliform concentrations. *E. Coli* has not been detected beneath the filter. Soon after the Floodway drains, surface water infiltration is flushed out quickly from the system as shown by a return to groundwater quality and an absence of bacteria. A return to groundwater quality (as shown by conductivity) was seen towards the end of the flood period as shown by transducer data.

7.0 GROUNDWATER RESPONSE PLAN

The Groundwater Action Response Plan has been used effectively during construction. Approximately 30 complaints were pertaining to construction projects from 2005 to 2010. No complaints were received in 2011.

8.0 POST-CONSTRUCTION AND LONG-TERM MONITORING










The Floodway Expansion Groundwater Monitoring Plan Final Report Version 1.0 was issued in August 2005. That report sets out the monitoring program goals and objectives and gives details of the baseline monitoring program. Plans for construction, post-construction and long term monitoring, analysis and reporting are also included.

The Long-Term Monitoring Plan (HM72) is being finalized and will be submitted to Manitoba Environment as part of the license requirements. Monitoring for 2010 and 2011 are considered as the first 2 years of a 5-year post construction monitoring period as construction activities with the potential to affect groundwater concluded in 2010 prior to the spring flood. Post-construction monitoring will continue in 2012, 2013 and 2014 to be followed by long-term monitoring in 2015 and after. Monitoring in 2012 and onward is proposed based on the magnitude and duration of the flood event as described in the plan.

FIGURES

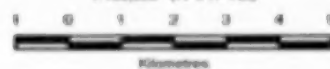


LEARNING

- | | |
|-------------------------------------------------------------------------------------|--------------------------------|
|  | Healthy Flight of My Love |
|  | 500 Reactions |
|  | Monitoring 90% |
| Customer Study Completed 2011 | |
|  | Capacity and Stability |
|  | Service Only |
| Summary | |
|  | Unrated (to Environment) |
|  | Treatment Site |
|  | Open 90% in 1 year into 2012 |
|  | Expanded (Normal) Use of Range |

[illegible]

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MANITOBA FLOODWAY AUTHORITY

FIG. 2. POWER PLANT ENERGY EXPANSION

2015 CIRC PATENTIVITY MEASUREMENTS ACTIVITY BY REGION

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DATE	TIME	LOCATION
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